

## ***Appendix J2***

### ***Structural and Seismic Engineering Design Criteria***

## **Structural and Seismic Engineering Design Criteria**

### **1.0 Introduction**

The project design, engineering, procurement, and construction activities will be in accordance with various predetermined standards and project-specific practices. This appendix summarizes the structural and seismic engineering codes and standards, design criteria, and practices that will be used during design and construction. These criteria form the basis for the project structural design work. More specific design information will be developed during detailed design to support equipment procurement and construction specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Section 2.0 summarizes the applicable codes and standards. Section 3.0 includes the general criteria for natural phenomena, design loads, materials, seismic design, and architecture. Section 4.0 describes the structural design methodology for structures and equipment. Section 5.0 addresses project hazard mitigation.

## **2.0 Design Codes and Standards**

### **2.1 General Requirements**

Work will be designed and specified in accordance with applicable laws and regulations of the Federal Government and the State of California and applicable local codes and ordinances. Except where noted otherwise, the latest issue of codes and standards, including addenda, in effect at the start of the project will be used. The codes and standards, including addenda, in effect at the time of purchase will be used for material and equipment procurement.

A summary of the codes and the standards to be used in design and construction follows:

- Seismic standards and criteria will follow the California Building Code (CBC).
- Specifications for materials will follow the standard specifications of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI), unless noted otherwise.
- Field and laboratory testing procedures for materials will follow ASTM standards.
- Structural concrete and reinforcing steel will be designed and placed in accordance with the codes, guides, and standards of the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI).
- Structural steel will be designed, fabricated, and erected in accordance with the American Institute of Steel Construction (AISC) Manual of Steel Construction-Allowable Stress Design.

- Steel components for metal wall panels and roof decking will conform to the American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members.
- Welding procedures and qualifications for welders will follow the recommended practices and codes of the American Welding Society (AWS).
- Metal surfaces for coating systems will be prepared following the specifications and standard practices of the Steel Structures Painting Council (SSPC) and the specific instructions of the coatings manufacturer.
- Masonry materials will be designed and erected in accordance with the ACI Building Code Requirements for Masonry Structures.
- Roof covering design will comply with the requirements of the National Fire Protection Association (NFPA) and Factory Mutual (FM).
- Design and construction will conform to federal and California Occupational Safety and Health Administration (OSHA and CAL/OSHA) requirements.

Other recognized standards will be used where required to serve as guidelines for design, fabrication, and construction. When no other code or standard governs, the CBC, 1998 Edition will govern.

## **2.2 Government Rules and Regulations**

The following laws, ordinances, codes, and standards are applicable to structural design and construction. In cases where conflicts between cited codes (or standards) exist, the requirements of the more stringent code will govern. The sections in the CBC have been quoted throughout this document as reference. These sections are based on the 1998 editions of CBC. However, the latest edition of CBC at the start of the project will apply to the engineering design.

### **2.2.1 Federal**

- Title 29, Code of Federal Regulations (CFR), Part 1910, Occupational Safety and Health Standards.
- Title 29, CFR, Part 1926, National Safety and Health Regulations for Construction.
- Walsh-Healy Public Contracts Act (Public Law [PL] 50-204.10).

### **2.2.2 State**

- Business and Professions Code Section 6704, et seq.; Sections 6730 and 6736. Requires state registration to practice as a Civil Engineer or Structural Engineer in California.

- Labor Code Section 6500, et seq. Requires a permit for construction of trenches or excavations 5 feet or deeper into which personnel will descend. This also applies to construction or demolition of any building, structure, false work, or scaffolding which is more than three stories high or equivalent.
- Title 24, California Code of Regulations (CCR) Section 2-111, et seq.; Section 3-100, et seq.; Section 4-106, et seq.; Section 5-1021, et seq.; Section 6-T8-769, et seq.; Section 6-T8-3233, et seq.; Section 6-T8-3270, et seq.; Section 6-T8-5138, et seq.; Section 6-T8-5465, et seq.; Section 6-T8-5531, et seq.; and Section 6-T8-5545, et seq. Adopts current edition of CBC as minimum legal building standards.
- Title 8 CCR Section 450, et seq. and Section 750, et seq. Adapts American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASMEB and PVC) and other requirements for unfired and fired boilers.
- Title 8, CCR Section 1500, et seq.; Section 2300, et seq.; and Section 3200, et seq. Describes general construction safety orders, industrial safety orders, and work safety requirements and procedures.
- Regulations of the following state agencies as applicable:
  - Department of Labor and Industry Regulations.
  - Bureau of Fire Protection.
  - Department of Public Health.
  - Water and Power Resources.

### **2.2.3 Local**

- California Building Code.

## **2.3 Industry Codes and Standards**

### **2.3.1 American Concrete Institute (ACI)**

- ACI 117--Standard Specification for Tolerances for Concrete Construction and Materials.
- ACI 211.1--Standard Practice for Selecting Proportions of Normal, Heavyweight, and Mass Concrete.
- ACI 301--Specifications for Structural Concrete for Buildings.
- ACI 302.1R--Guide for Concrete Floor and Slab Construction.
- ACI 304R--Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- ACI 305R--Hot Weather Concreting.
- ACI 306R--Cold Weather Concreting.
- ACI 308--Standard Practice for Curing Concrete.
- ACI 309R--Guide for Consolidation of Concrete.
- ACI 311AR--Guide for Concrete Inspection.
- ACI 318--Building Code Requirements for Reinforced Concrete.
- ACI 318.1--Building Code Requirements for Structural Plain Concrete.
- ACI 347R--Guide to Formwork for Concrete.
- ACI 530--Building Code Requirements for Masonry Structures.
- ACI 530.1--Specifications for Masonry Structures.

### **2.3.2 American Institute of Steel Construction (AISC)**

- Code of Standard Practice for Steel Buildings and Bridges.
- Manual of Steel Construction-Allowable Stress Design.
- Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
- Allowable Stress Design Specification for Structural Joints Using ASTM A325 or A490 Bolts.

### **2.3.3 American Iron and Steel Institute (AISI)**

- Specification for the Design of Cold-Formed Steel Structural Members.

### **2.3.4 American Society for Testing and Materials (ASTM)**

- ASTM A36--Standard Specification for Structural Steel.
- ASTM A53--Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

- ASTM A82--Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
- ASTM A106--Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
- ASTM A108--Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.
- ASTM A123--Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- ASTM A153--Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- ASTM A185--Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
- ASTM A240--Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
- ASTM A276--Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
- ASTM A307--Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- ASTM A325--Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
- ASTM A446--Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality.
- ASTM A500--Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
- ASTM A501--Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
- ASTM A569--Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial Quality.
- ASTM A615--Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- ASTM B695--Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
- ASTM C31--Standard Practice for Making and Curing Concrete Test Specimens in the Field.
- ASTM C33--Standard Specification for Concrete Aggregates.

- ASTM C39--Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- ASTM C90--Standard Specification for Load-Bearing Concrete Masonry Units.
- ASTM C94--Standard Specification for Ready-Mixed Concrete.
- ASTM C109--Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 in. or 50 mm Cube Specimens).
- ASTM C129--Standard Specification for Non-Load-Bearing Concrete Masonry Units.
- ASTM C136--Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
- ASTM C138--Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.
- ASTM C143--Standard Test Method for Slump of Hydraulic Cement Concrete.
- ASTM C150--Standard Specification for Portland Cement.
- ASTM C172--Standard Practice for Sampling Freshly Mixed Concrete.
- ASTM C231--Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
- ASTM C260--Standard Specification for Air-Entraining Admixtures for Concrete.
- ASTM C270--Standard Specification for Mortar for Unit Masonry.
- ASTM C289--Standard Test Method for Potential Reactivity of Aggregates (Chemical Method).
- ASTM C494--Standard Specification for Chemical Admixtures for Concrete.
- ASTM C586--Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method).
- ASTM C618--Standard Specification for Coal Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
- ASTM C1064--Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.
- ASTM C1107--Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink).
- ASTM D1752--Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
- ASTM E329--Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

**2.3.5 American Society of Mechanical Engineers (ASME)**

- Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels, Division 2 - Alternative Rules.
- ASME/STS-1, Steel Stacks.

**2.3.6 American Society of Civil Engineers (ASCE)**

- ASCE 7--Minimum Design Loads for Buildings and Other Structures.

**2.3.7 American Water Works Association (AWWA)**

- AWWA D100--Welded Steel Tanks for Water Storage.

**2.3.8 American Welding Society (AWS)**

- AWS DI.1--Structural Welding Code - Steel.
- AWS DI.4--Structural Welding Code - Reinforcing Steel.

**2.3.9 California Energy Commission**

- Recommended Seismic Design Criteria for Non-Nuclear Generating Facilities in California.

**2.3.10 Concrete Reinforcing Steel Institute (CRSI)**

- Manual of Standard Practice.

**2.3.11 International Conference of Building Officials**

- CBC--California Building Code.

**2.3.12 Metal Building Manufacturers Association (MBMA)**

- Low Rise Building Systems Manual.

**2.3.13 National Fire Protection Association (NFPA)**

- NFPA 22--Standard for Water Tanks for Private Fire Protection.
- NFPA 24--Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
- NFPA 80--Standard for Fire Doors and Fire Windows.
- NFPA 850--Recommended Practice for Fire Protection for Electric Generating Plants.



**2.3.14 Steel Structures Painting Council (SSPC)**

- Steel Structures Painting Manual, Volume 2, Systems and Specifications.

**3.0 Structural Design Criteria****3.1 Natural Phenomena**

The design criteria based on natural phenomena are discussed in this section. The climatological data listed were retrieved from the Local Climatological Data, Annual Summaries for 1998, Stockton, CA. The data cover a period of record from 1937 to 1998. The detail design will be based on the latest available data at the start of the project.

**3.1.1 Rainfall**

- Maximum 24 Hour: 3.01 inches.
- Maximum Monthly: 8.22 inches.
- Normal Annual: 13.95 inches.

The rainfall design basis may vary for the different systems and system components. Precipitation amounts and intensities to be used with each design basis for various durations and return periods will be obtained from TR-25.

**3.1.2 Wind Speed**

The maximum recorded 5-second wind speed for 1998 is 54 mph. The maximum recorded 2-minute wind speed is 41 mph. The Annual Summary for Local Climatological Data recently introduced 5-second and 2-minute measurements for wind speed. As a result, the Period of Record (POR) for these measurements is only 2 years.

The design basic wind speed will be 70 miles per hour, as determined from Figure No. 16-1 of California Building Code. This design wind speed will be used to determine wind loads for all structures as discussed in Section 3.2.3, Wind Loads.

**3.1.3 Temperature**

- Maximum: 114° F (1972).
- Minimum: 17° F (1990).
- Normal Dry Bulb: 61.6° F.

**3.1.4 Relative Humidity**

The relative humidity ranges from 26 to 90 percent.

### **3.1.5 Seismicity**

The plant site is located in Seismic Zone 4, as determined from Figure 16-2 of the CBC.

### **3.1.6 Snow**

The plant site is located in a zero ground snow load area.

## **3.2 Design Loads**

### **3.2.1 Dead Loads**

Dead loads include the weight of all components forming the permanent parts of structures and all permanent equipment. The dead load of permanent plant equipment will be based on actual equipment weights. For major equipment, structural members and foundations will be specifically located and designed to carry the equipment load into the structural system. For equipment weighing less than the uniform live load, the structural system will be designed for the uniform live load.

The contents of tanks and bins at full operating capacity will be considered as dead loads. The contents of tanks and bins will not be considered effective in resisting uplift due to wind forces, but will be considered effective for seismic forces.

A uniform load of 50 psf will be used to account for piping and cable trays, except in administration building areas, and will be carried to the columns and foundations as dead loads. Uniform piping and cable tray loads will not be considered effective in resisting uplift due to wind forces, but will be considered effective for seismic forces. Additional piping loads will be considered in the design of areas with heavy piping concentrations. After critical and/or heavy piping hanger loads and locations are established, the supporting members will be reviewed for structural adequacy.

For piperacks, the weight of piping and cable trays will be treated as live load.

### **3.2.2 Live Loads**

Live loads are the loads superimposed by the use and occupancy of the building or structure. They do not include wind loads, snow loads, or seismic loads.

Uniformly distributed live loads are specified to provide for movable and transitory loads, such as the weight of people, office furniture and partitions, portable equipment and tools, and other nonpermanent materials. These uniform live loads will not be applied to floor areas permanently occupied by equipment, with no access beneath. Uniform live loads for equipment lay-down areas will be based on the actual weight and size of the equipment and parts that may be temporarily placed on floors during dismantling, maintenance, installation, or removal.

The design live loads will be as follows:

- **Ground Floor (Grade Slab)**--A uniform load of 250 psf, nonpermanent equipment weights, storage weights, or lay-down weights, whichever is greater, will be used.
- **Grating Floors, Platforms, Walkways, and Stairs**--A uniform live load of 100 psf will be used. In addition, a concentrated load of 2 kips will be applied concurrently to the supporting beams to maximize stresses in the members, but the reactions from the concentrated load will not be carried to columns. Maximum deflection of the grating will be limited to 1/200 of the span.
- **Elevated Concrete Slabs**--A uniform load of 100 psf, nonpermanent equipment weights, storage weights, or lay-down weights, whichever is greater, will be used.

Elevated concrete slabs will be designed to support either the prescribed live load or a single concentrated load of 2 kips, whichever produces the greater stresses. The concentrated load will be treated as a uniformly distributed load acting over an area of 2.5 square feet and will be located to produce the maximum stress conditions in the slab.

Metal decking for concrete slabs will be designed for a load during construction equal to the weight of concrete plus 50 psf (no increase in allowable stress).

- **Roof**--Roof areas will be designed for a minimum live load of 20 psf. Ponding loading effect due to roof deck and framing deflections will be investigated in accordance with Section K2 of the AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design.
- **Piperacks**--A minimum uniform load of 100 psf will be used for each level of the piperacks, except that, where piping and cable tray loads exceed 100 psf, the actual loads will be used. In addition, a concentrated load of 5 kips will be applied concurrently to the supporting beams to maximum stresses in the members, but the reactions from the concentrated loads will not be carried to columns.
- **Truck Loads**--A surcharge load of 250 psf will be applied to plant structures accessible to truck traffic.

Roads pavements, underground piping, conduits, sumps, and foundations subject to truck traffic will be designed for wheel loadings in accordance with Appendix H1, Section 3.2.2.

- **Thermal Forces**--Thermal forces caused by thermal expansion of equipment and piping under all operating conditions will be considered.
- **Dynamic Loads**--Dynamic loads will be considered and applied in accordance with the manufacturer's criteria/recommendations and industry standards.

### **3.2.3 Wind Loads**

Wind loads for structures and their components will be determined in accordance with the California Building Code, using a basic wind speed of 70 mph at 33 feet above grade. Category 3 and an Importance Factor of 1.0 will be used.

### **3.2.4 Seismic Loads**

Seismic loads will be determined in accordance with the requirements specified in Section 3.4.

### **3.2.5 Other Loads**

Other expected loads required to predict the structural response of structures will be considered where appropriate (i.e., water hammer, test loads, etc.).

### **3.2.6 Load Combinations**

Applicable code-prescribed load combinations will be considered in the design of structures. As a minimum, the following load combinations will be considered:

- Dead load.
- Dead load + live load + operating loads.
- Dead load + live load + operating loads + wind load.
- Dead load + live load + operating loads + seismic load.
- Dead load + construction loads.
- Dead load + live load + emergency loads.
- Dead load + wind load.
- Dead load + seismic load.

Operating loads include all loads associated with normal operation of the equipment (e.g., temperature and pressure loads, piping loads, normal torque loads, impact loads, etc.).

### **3.2.7 Strength Requirements**

Each load combination will not exceed the stress or strength levels permitted by the appropriate code for that combination.

**3.2.7.1 Concrete Structures.** The required strength (U) of concrete structures will be at least equal to the following:

- $U = 1.4 \text{ Dead} + 1.7 \text{ Live}.$
- $U = 0.75 (1.4 \text{ Dead} + 1.7 \text{ Live} + 1.7 \text{ Wind}).$
- $U = 0.9 \text{ Dead} + 1.3 \text{ Wind}.$
- $U = 0.75 (1.4 \text{ Dead} + 1.7 \text{ Live} + 1.87 \text{ Seismic}).$

- $U = 0.9 \text{ Dead} + 1.43 \text{ Seismic}.$
- $U = 1.4 \text{ Dead} + 1.7 \text{ Live} + 1.7 \text{ Earth Pressure}.$
- $U = 0.9 \text{ Dead} + 1.7 \text{ Earth Pressure}.$

**3.2.7.2 Steel Structures.** The required strength (S) based on elastic design methods and allowable stresses (without 1/3 increase allowed for wind or seismic loading) defined in the AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, will be at least equal to the following:

- $S = \text{Dead}.$
- $S = \text{Dead} + \text{Live}.$
- $S = 0.75 (\text{Dead} + \text{Wind}).$
- $S = 0.75 (\text{Dead} + \text{Seismic}).$
- $S = 0.75 (\text{Dead} + \text{Live} + \text{Wind}).$
- $S = 0.75 (\text{Dead} + \text{Live} + \text{Seismic}).$

For load combinations including seismic loading, frame members and connections will conform to the additional requirements of Sections 1633 and 2213 of the CBC.

### 3.2.8 Factors of Safety

Minimum factors of safety for foundations supporting structures, tanks, and equipment supports will be as follows:

- Overturning--1.50.
- Sliding:
  - 1.10 for seismic load.
  - 1.50 for wind load.
- Buoyancy--1.25.
- Uplift due to wind--1.50.

## 3.3 Materials

### 3.3.1 Structural Steel

**3.3.1.1 General.** Structural steel will conform to ASTM A36 or other materials as required and accepted for use by the AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design.

High strength bolts for connections will conform to ASTM A325. Bolts other than high strength bolts will conform to ASTM A307, Grade A. Nonheaded anchor bolts will conform to ASTM A36, unless higher strength bolting materials are required by design. Drilled-in expansion bolts for concrete will be Hilti-Kwik Bolts or equivalent.

Structural steel will be detailed and fabricated in accordance with the AISC Code of Standard Practice and the AISC Specification for Structural Steel Buildings. Structural material

will be fabricated and assembled in the shop to the greatest extent possible. Structural members will be welded in accordance with AWS D1.1. Columns will be milled to bear on the baseplate or cap plate. Connections will have a minimum of two bolts.

Exterior structural steel will be either hot-dip galvanized or shop primed and finish painted after installation. Interior structural steel will be shop primed after fabrication. Surface preparation and painting will be in accordance with SSPC standards. Galvanizing will be in accordance with the requirements of ASTM standards.

**3.3.1.2 Design and Testing.** Steel structures will be designed by the Working Stress Method in accordance with the CBC and the AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design. Connections will be in accordance with the AISC Manual of Steel Construction and the AISC Allowable Stress Design Specification for Structural Joints Using ASTM A325 or A490 Bolts.

Steel structures will be designed as “rigid frame” (AISC Specification Type 1) or “simple framing” (AISC Specification Type 2), using single-span beam systems, vertical diagonal bracing at main column lines, and horizontal bracing at the roof and major floor levels.

Type 1 rigid frames will be generally limited to prefabricated metal buildings. All other framed structures will use Type 2 design and construction.

Metal roof and floor decking attached with appropriate welding or fasteners may be considered effective as horizontal diaphragms, provided they are previously qualified by the manufacturer. Grating floors will not be considered as providing horizontal rigidity.

Mill test reports or certificates of conformance certifying that material is in conformance with the applicable ASTM specification will be required. In addition, the fabricator will be required to provide an affidavit stating that steel has been furnished in accordance with the requirements of the drawings and the specifications, including specified minimum yield strength.

**3.3.1.3 Handrails, Guardrails, and Toe Plates.** Handrails and/or guardrails, except for preengineered equipment, will be fabricated from standard weight steel pipe and fittings, either galvanized or painted. Handrails will have toe plates where there is no curb.

**3.3.1.4 Steel Grating and Grating Stair Treads.** The steel to be used for grating and grating treads will conform to either ASTM A36 or ASTM A569. Grating will be rectangular and consist of welded steel construction. Grating will be hot-dip galvanized after fabrication.

Stair treads will have nonslip abrasive nosing and will have end plates for attaching to stringers. Outdoor grating will have a serrated surface.

The Hilti Grating Disk system, or equivalent, will be used for fastening. Grating will have at least a 1-inch bearing support.

Floor and platform openings necessitated by expansion and movement requirements around piping and equipment will be protected as follows:

- Openings more than 1-1/2 inches wide around penetrating objects will be protected by toe plates.
- Openings more than 8 inches wide around penetrating objects will be protected by toe plates and handrails.

**3.3.1.5 Stairs and Ladders.** Stairs will be the means of travel from one elevation to another. Vertical ladders, ship ladders, etc., will be installed only where personnel access is infrequent.

Fixed ladders will have safety cages and/or other fall prevention devices as required by the applicable codes and regulations. Stairs will have handrails on both sides.

### **3.3.2 Concrete and Reinforcing Steel**

**3.3.2.1 General.** Materials for concrete will comply with ACI 301. Cement will be portland cement meeting the requirements of ASTM C150. Fine aggregates will be clean natural sand. Coarse aggregates will be crushed stone or gravel. Aggregates will conform to the chemical and physical requirements of ASTM C33. Only clean water of potable quality and satisfying the requirements of ASTM C94 will be used.

Admixtures such as plasticizers and retarders may be used to improve workability and control setting time. Concrete will have an entrained air content between 3 and 6 percent by volume. Air-entraining admixtures will meet ASTM C260 requirements. Water reducing admixtures will conform to ASTM C494, Type A. Calcium chloride or admixtures containing calcium chloride will not be used.

Concrete reinforcing will be deformed bars of intermediate grade billet steel conforming to ASTM A615, Grade 60, or welded wire fabric conforming to ASTM A185.

**3.3.2.2 Mix Design.** Concrete mix designs will be proportioned and furnished in accordance with ACI 211.1, ASTM C94, and CBC Section 1905. Proportions for the concrete mixture will be selected to meet the strength requirements specified in design documents. Generally, a minimum concrete compressive strength of 4,000 psi at 28 days will be required for structural concrete. Final concrete mix designs will be established based on historical strength performance data or trial mixtures meeting the requirements of Section 1905 of the CBC.

**3.3.2.3 Testing and Material Certification.** Certified mill test reports on chemical and physical properties confirming compliance with ASTM C150 will be required for each shipment of cement used.

Certificates of Conformance will be obtained from the supplier, certifying that aggregates used comply with the chemical and physical requirements of ASTM C33. Gradation analyses of fine and coarse aggregates, performed in accordance with ASTM C136, will also be provided.

The manufacturer will certify that the admixture provided conforms to the specified ASTM standard and that it contains no chlorides except those that may be contained in the water used in manufacturing the admixture.

The slump, air content, and temperature of the concrete at the point of discharge from the conveying vehicle will be tested in accordance with specified minimum testing frequencies. Concrete strength will be evaluated in accordance with ASTM C94 and CBC Section 1905.

Mill test reports certifying that reinforcing steel is in accordance with ASTM and project specifications will be required.

**3.3.2.4 Design.** Reinforced concrete structures will be designed by the Ultimate Strength Method in accordance with the CBC and ACI 318, Building Code Requirements for Reinforced Concrete.

## **3.4 Seismic Design Criteria**

This section provides the general criteria and procedures to be used for the seismic design of buildings, structures, and structural components.

### **3.4.1 Seismic Performance Objectives**

The seismic performance objectives for this facility are as follows:

- Resist minor levels of earthquake ground motion without damage.
- Resist moderate levels of earthquake ground motion without structural damage, but with some nonstructural damage.
- Resist major levels of earthquake ground motion without collapse, but with some structural as well as nonstructural damage.

To achieve these objectives and to meet the requirements of the California Energy Commission (CEC) and local codes, the facility will be designed in accordance with the CBC.

### **3.4.2 General Criteria**

The plant site is located in Seismic Zone 4 according to CBC Figure 16-2, Seismic Zone Map of the United States. For seismic load calculations, the Importance Factor for Category 3 structures (power plants) is 1.00 based on the 1998 CBC (Table 16-K).

Buildings and structures conforming to CBC Section 1629.8.3 will be designed using the static lateral force procedure of CBC Section 1630. Nonbuilding structures will be designed in accordance with CBC Section 1634.

Buildings and structures conforming to CBC Section 1629.8.4 will be designed using the dynamic lateral force procedure of CBC Section 1631. The ground motion representation used will be the elastic design response spectrum constructed in accordance with CBC Figure 16-3.

Lateral forces on elements of structures and nonstructural components supported by structures will be determined in accordance with CBC Section 1632 requirements.

Water storage tanks will meet the seismic design requirements of AWWA D100, Appendix H1.



## **3.5 Architecture**

### **3.5.1 General**

Architectural work will be in accordance with the applicable laws, ordinances, codes and industry standards, design criteria, guidelines, general requirements, and material selection specified in this section.

The plant will be laid out to accommodate the spaces required for plant equipment and operations. Aisles and clearances will provide access for operation, minor maintenance, and equipment removal. Personnel walkways to equipment (for routine maintenance only), doors, stairs, and other access points will be provided. Plant security and life safety features will also be considered in the plant layout.

### **3.5.2 Criteria**

These criteria are intended to govern the architectural design of structures and facilities.

Safety, construction, fire protection and fire walls, and requirements for the physically handicapped will be in accordance with the requirements of the applicable local, state, and national codes and standards. Requirements of the Americans with Disabilities Act will also be included in the design where applicable.

Plant buildings will be single story preengineered buildings with insulated siding. For sloping roofs, roofing will be standing seam metal with insulation and a vapor barrier; for flat roofs, roofing will be single-ply membrane over metal decking with insulation. The Administration/Maintenance Building will house the control room, administrative offices, men's and women's toilets, conference room, lunchroom, utility rooms, and a warehouse/maintenance shop. The warehouse/maintenance shop, electrical rooms, and HVAC equipment spaces will have exposed structure. The remaining areas will have suspended acoustical ceilings.

Reinforced concrete grade slabs will be treated with a sealer and/or floor hardener, as applicable, to accommodate maintenance or laydown. Interior wall partitions will be concrete block masonry, concrete, or gypsum wallboard on metal studs. Stairs will be concrete, galvanized grating, or checkered plate. Floor drains will be provided as necessary.

### **3.5.3 Materials**

Asbestos- and lead-containing materials will not be used in the facility.

**3.5.3.1 Concrete Masonry.** Concrete masonry unit (CMU) partitions will generally be used in traffic and spillage areas, in toilets and locker rooms, in the battery and electrical rooms, and as fire boundaries where required by code.

CMU will be both hollow, normal weight, nonload-bearing Type I conforming to ASTM C129, and load-bearing Grade N, Type I conforming to ASTM C90. Mortar will conform to ASTM C270, Type M. CMU will be reinforced as required.

Masonry structures will be designed and constructed in accordance with ACI 530, Building Code Requirements for Masonry Structures; ACI 530.1, Specifications for Masonry Structures; and Chapter 21 of the CBC.

**3.5.3.2 Preformed Metal Siding.** Exterior siding will be either an insulated or an uninsulated field assembled system. Exterior face panels will be 24 gauge minimum; interior face panels will be 22 gauge minimum. Panels will be fabricated from galvanized sheet steel.

The wall system will be designed to withstand the specified wind loading with practical and economical support girt spacing.

Wall insulation will be noncombustible glass fiber to produce a maximum U-factor of 0.08 Btu/h/ft/F.

**3.5.3.3 Metal Studwall Partitions.** Except when CMU partitions are required, ceiling height interior partitions will generally be of metal stud and painted gypsum board construction.

**3.5.3.4 Roofing.** Roofing will be either single-ply membrane over rigid insulation board, mechanically fastened to the metal roof deck, or standing seam metal with insulation and vapor barrier. The completed roofing system will conform to UL requirements for Class A roofs and to Factory Mutual wind uplift Class 90. The completed roof will have an overall maximum U-factor of 0.05 Btu/h/ft/F.

**3.5.3.5 Metal Roll-Up Doors.** Roll-up doors will have insulated door curtains constructed of interlocking roll-formed galvanized steel slats to withstand the specified wind pressure. Doors will be manually operated.

**3.5.3.6 Hollow Metal Doors, Frames, and Hardware.** Personnel doors will be flush hollow metal on pressed steel door frames, with hinges, locksets, closers, weatherstripping, and accessory hardware. Fire doors and frames will conform to NFPA 80 for the class of door furnished.

**3.5.3.7 Louvers.** Louvers will be operable, extruded aluminum section alloy, with stainless steel fastenings and removable aluminum bird screen. Blades will be stormproof. Louver free area will be a minimum of 50 percent of louver face area. Louvers will be designed for manual or gravity operation.

**3.5.3.8 Floor Finish.** Floor finishes will generally be concrete with curing and sealing protection.

The battery room and other chemical areas will generally receive special coatings.

### **3.5.4 Painting**

Generally, exposed wall surface, structures, and structural components will be prime painted or otherwise treated to protect them from corrosion in accordance with the applicable codes, industry standards, and manufacturer's recommendations.

**3.5.4.1 Structural and Miscellaneous Steel.** Structural and miscellaneous steel will receive shop applied inorganic zinc primer. Field touchup will be performed after erection. Structural steel requiring fireproofing will either receive no painting or a primer compatible with the selected fireproofing material.

**3.5.4.2 Masonry Walls and Concrete Walls and Floors.** Concrete floors in areas not exposed to chemical contaminants will not be coated. Indoor masonry walls in areas requiring paint but not exposed to chemical contaminants will be painted with one coat of acrylic filler and a compatible finish coat.

**3.5.4.3 Gypsum Wallboard.** Exposed surfaces will receive one coat each of sealer and compatible acrylic finish.

## **4.0 Structural Design Methodology**

This section describes the structural aspects of the design of the proposed facility. Each major structural component of the plant is addressed by defining the design criteria and analytical techniques that will be employed.

### **4.1 Structures**

#### **4.1.1 Combustion Turbine Foundations**

The combustion turbine foundations will be designed to support the turbine and generator components.

Each foundation will be designed to resist the loadings furnished by the manufacturer plus loadings from natural phenomena and structural framing, if applicable, and will be constructed of reinforced concrete.

**4.1.1.1 Foundation Loads.** Equipment foundation loads will be furnished by the combustion turbine manufacturer and will be combined with the other loads imposed on the foundation. Typical loading data supplied by the manufacturer include the following. The combustion turbine foundations will be designed for these loads:

- Dead loads.
- Live loads.
- Wind loads.
- Seismic loads.
- Normal torque loads.

- Normal machine unbalance loads.
- Emergency loads, such as turbine accident or generator short circuit.
- Thermal loads due to thermal expansion or contraction of the machines, connected piping, and turbine pedestal components.
- Shrinkage and creep loads.

**4.1.1.2 Induced Forces.** The combustion turbines and associated equipment will be securely anchored to their foundations using cast-in-place steel anchor bolts designed to resist the equipment forces and seismic or wind loads.

**4.1.1.3 Structural System.** The combustion turbine foundation system will consist of a reinforced concrete mat bearing directly on undisturbed soil or compacted fill.

**4.1.1.4 Structural Criteria.** Each foundation will be designed and constructed as a monolithic reinforced concrete structure using the criteria from Section 3.0 and Appendix H1, Section 3.1. The foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Equipment, structure, and environmental loads.
- Factors of safety against overturning and sliding.
- Equipment performance criteria.
- Natural frequencies and dynamic effects of rotating equipment.
- Access and maintenance.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Environmental loadings will be determined in accordance with Sections 3.1 and 3.2. Foundation seismic loading will be calculated as specified in Section 3.4. Seismic forces will be applied at the center of gravity of the equipment.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

**4.1.1.5 Analytical Techniques.**

**Combustion Turbine Foundation.** The mat foundation for the combustion turbine will be designed using static analysis techniques. If adequate rigidity is provided, the mat will be analyzed as a rigid mat foundation to determine the resulting soil pressures and internal forces and moments. The foundation will be analyzed assuming a linear soil pressure distribution.

If its rigidity is in question, the foundation mat will be considered as a flexible system and modeled as a plate structure using 3-D plate bending elements. The interaction between the

mat and supporting soil will be modeled using a system of vertical and horizontal springs attached to a fixed boundary. A computer analysis will be performed using finite element techniques.

The foundation will be checked for dynamic response to the operating turbine. A dynamic analysis will typically be performed by considering the mat foundation as rigid and using a lumped mass model. The lumped mass model will include soil springs and dashpots to account for soil and structure interaction. An analysis will be performed to determine the natural frequencies of the foundation using the lumped mass model. When the rigidity of the mat foundation is in question, the mat will be considered flexible and will be modeled by plate elements, and a dynamic analysis will be performed using finite element computer analysis.

To avoid resonance during machine operation, the resonant frequency of the foundation will typically be less than 80 percent or greater than 120 percent of the machine operating speed.

#### **4.1.2 Stacks and Foundations**

Each stack will be carbon steel with a separate reinforced concrete mat foundation bearing directly on undisturbed soil or compacted fill.

**4.1.2.1 Foundation Loads.** Foundation loads will be determined using project-specific design criteria. The design will include the following loads:

- Dead load.
- Live loads.
- Wind loads.
- Seismic loads.
- Temperature and pressure loads.

**4.1.2.2 Induced Forces.** The stack will be securely anchored to its foundation using cast-in-place steel anchor bolts designed to resist the stack-induced forces.

**4.1.2.3 Structural System.** The steel stack will consist of a cylindrical steel shell that resists lateral loading as a fixed-base, cantilevered structure. The stack foundation system will consist of a reinforced concrete mat bearing directly on undisturbed soil or compacted fill.

**4.1.2.4 Structural Criteria.** The predominant forces acting on the stack will result from wind or seismic loading. The stack will be designed as indicated in this section.

The steel stack and supports will be capable of enduring specified normal and abnormal design operating conditions in combination with wind or seismic loads for the design life of the facility. The design will be in accordance with the design methods of ASME STS-1, Steel Stacks, and the AISC Manual of Steel Construction - Allowable Stress Design, except that increased allowable stresses for wind or seismic loadings will not be used.

Design values for yield strength and modulus of elasticity of the stack material will depend on the composition of the material and the maximum temperature of the metal at design

operating conditions and will be as prescribed by the ASME Pressure Vessel Code, Section VIII, Division 2, Part AM.

Wind loads will be determined from the CBC, using Exposure Category C. Consideration will be given to along-wind and across-wind responses, ovaling, and interference effects. Seismic loads will be determined in accordance with CBC Section 1634, Nonbuilding Structures.

The allowable longitudinal, circumferential, and shear stresses for the design of the stack shell will be determined in accordance with ASME STS-1.

The minimum shell thickness will be 1/4 inch plus 1/16 inch corrosion allowance. The corrosion allowance will be considered in the generation of seismic loads but not in the resistance to seismic or wind loads. Allowable stresses for stiffeners, platform members, and other miscellaneous steel components will be in accordance with the AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design. Allowable stresses for the shell will not be increased for wind or seismic loadings.

Each foundation will be designed and constructed as a monolithic reinforced concrete structure using the criteria from Section 3.0 and Appendix H1, Section 3.1. The foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Structure and environmental loads.
- Factors of safety against overturning and sliding.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

**4.1.2.5 Analytical Techniques.** Stack moments, shears, and axial forces will be calculated using static analysis procedures on a cantilevered member. Longitudinal stresses resulting from axial loads and flexure will be combined and compared to a single allowable stress.

Circumferential stresses will also be compared to a single allowable value. Interaction between longitudinal and circumferential stresses will be considered.

The stack foundation will typically be designed using static analysis techniques assuming a rigid mat.

### **4.1.3 Buildings and Enclosures**

The various plant buildings and enclosures will provide support, protection, and access to the systems contained within their boundaries. Generally, each building and enclosure will be one story and preengineered.

**4.1.3.1 Foundation Loads.** Foundation loads will be determined from the analysis and design of the superstructure and from the support of the equipment contained within the structure. The following loads will be considered:

- Dead loads.
- Live loads.
- Equipment and piping loads.
- Wind loads.
- Seismic loads.

**4.1.3.2 Induced Forces.** Each building and enclosure will be securely anchored to its foundation using cast-in-place steel anchor bolts designed to resist any induced forces.

**4.1.3.3 Structural System.** Buildings and enclosures will be designed as AISC Type 1 rigid frames or as Type 2 simple braced frames. For the purpose of resisting seismic lateral loads, the structures will be classified as regular structures with a concentric braced frame, an ordinary moment-resisting frame, or a special moment-resisting frame, in accordance with the definitions of the CBC Chapters 16 to 22.

The foundation systems for buildings and enclosures will consist of individual spread footings to resist the column loads with an isolated slab-on-grade floor system.

**4.1.3.4 Structural Criteria.** Building and enclosure steel frames will be designed and constructed using the materials and criteria set forth in Section 3.0.

Environmental loading will be determined in accordance with Sections 3.1 and 3.2. Seismic loading for the buildings and enclosures will be calculated using equivalent static lateral forces applied to the structure in accordance with the procedures of CBC Section 1630 or dynamic lateral forces in accordance with CBC Section 1631.

Building and enclosure foundations will be designed and constructed using reinforced concrete according to the criteria set forth in Section 3.0 and Appendix H1, Section 3.1. The foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Equipment, structure, and environmental loads.
- Factors of safety against overturning and sliding.
- Equipment performance criteria.
- Access and maintenance.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

**4.1.3.5 Analytical Techniques.** Building and enclosure foundations will be designed as simple spread footings or mat foundations, using static analysis techniques. The foundations will be analyzed assuming a linear soil pressure distribution.

## **4.2 Tanks**

### **4.2.1 Field-Erected Storage Tanks**

Field-erected storage tanks will typically be vertical, cylindrical shells of stainless steel or carbon steel construction with a protective interior coating. Tank roofs will be either self-supported domes or cones. Tank bottoms will be ground-supported, flat-bottomed, with a slope of 1 percent. Tanks will have ladders, landing platforms, and handrails to provide access to working areas. Vents, manholes, overflow piping, and grounding lugs will be provided as necessary.

**4.2.1.1 Foundation Loads.** Foundation loads will be determined using project-specific design criteria. Tank and foundation design will include the following loads:

- Dead loads (including contained fluid load).
- Live loads.
- Wind loads.
- Seismic loads (including hydrodynamic loads).

**4.2.1.2 Induced Forces.** Storage tanks will be securely anchored to their foundations using cast-in-place steel anchor bolts designed to resist tank-induced forces.

**4.2.1.3 Structural System.** Each tank will be a cylindrical steel shell that resists lateral loading through shear in the tank wall. Anchor bolts connecting the tank wall to the foundation will resist overturning.

The tank foundation system will typically consist of a reinforced concrete ringwall or mat foundation. The interior of the ring will consist of compacted backfill with a layer of compacted sand to serve as a bearing surface for the tank bottom. If soil conditions could result in excessive settlements or soil overstress, a complete concrete mat may be required.

**4.2.1.4 Structural Criteria.** Tank structures will be designed and constructed using the criteria established in AWWA D100 or NFPA 22, as applicable.



Foundations will be designed and constructed as reinforced concrete structures using the criteria from Section 3.0 and Appendix H1, Section 3.1. Foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Fluid, structure, and environmental loads.
- Factors of safety against overturning and sliding.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Environmental loadings will be determined in accordance with Sections 3.1 and 3.2. Seismic loads will be determined in accordance with Section 3.4 and AWWA D100, Section 13.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7 and in Section 3 of AWWA D100. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

Tank foundation design will include the moment resulting from lateral displacement (hydrodynamics) of the tank contents in accordance with AWWA D100, Section 13.3.3.2.

**4.2.1.5 Analytical Techniques.** Tank foundations will typically be designed as circular ringwalls using static analysis techniques. Each ringwall will be proportioned to resist the design load of the tank and the maximum overturning moment due to wind or seismic loading. The ringwall will also be proportioned to resist maximum anchor bolt uplift force. Circumferential reinforcing steel will be provided in the ringwall to develop the hoop stress produced by the lateral soil pressure within the ringwall.

Tank structures will be designed and proportioned so that during the application of any load, or combination of loads, the allowable stresses stipulated in AWWA D100 are not exceeded.

## **4.2.2 Shop Fabricated Storage Tanks**

Shop fabricated storage tanks will be either vertical or horizontal, cylindrical, carbon steel shells. The tanks will have ladders, landing platforms, and handrails, to provide access to working areas. Each tank will have nozzles for fill connection, fill drain, overflow, vent connections, manholes, and grounding lugs as necessary.

**4.2.2.1 Foundation Loads.** Foundation loads will be furnished by the tank manufacturer and will be superimposed with loads for the foundation itself.

Typical loadings supplied by the manufacturer include the following:

- Dead loads.

- Live loads.
- Wind loads.
- Seismic loads (including hydrodynamic loads).
- Temperature and pressure loads.

**4.2.2.2 Induced Forces.** Each tank will be securely anchored to its foundation using cast-in-place steel anchor bolts or concrete expansion anchors designed to resist tank-induced forces.

**4.2.2.3 Structural System.** Each tank will consist of a cylindrical steel shell, either supported by integral legs or saddle supports, or with a flat bottom bearing directly on the foundation.

Foundations will typically consist of individual pads bearing directly on undisturbed soil or compacted fill. For tanks located in buildings, the pads may be constructed integrally with the grade slab.

**4.2.2.4 Structural Criteria.** Tanks will be designed by a tank manufacturer in accordance with the relevant ASME code, ANSI code, and ASTM standards.

Foundations will be designed and constructed as monolithic reinforced concrete structures using the criteria from Section 3.0 and Appendix H1, Section 3.1. Foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Fluid, structure, and environmental loads.
- Factors of safety against overturning and sliding.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Environmental loadings will be determined in accordance with Sections 3.1 and 3.2. Seismic loading will be calculated using equivalent static lateral forces applied at the center of gravity of the tank or tank component in accordance with the criteria specified in Section 3.4.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

**4.2.2.5 Analytical Techniques.** The tank foundations will typically be designed using static analysis techniques assuming a rigid mat. The foundations will be analyzed assuming a linear soil pressure distribution. The mats will be proportioned so that the resultant of the soil pressure coincides as nearly as possible with the resultant of the vertical loading.

The tanks will be designed and analyzed by a tank manufacturer to satisfy the requirements of the relevant ASME code, ANSI code, and ASTM standards.

### **4.3 Equipment and Equipment Foundations**

Plant equipment will be designed in accordance with manufacturers' standards and applicable codes and industry standards. Equipment will be designed to resist project-specific environmental loadings, as applicable.

Foundations will be designed to resist the loadings furnished by the manufacturers and will be constructed of reinforced concrete.

Specific criteria for the combustion turbine foundations are addressed in Section 4.1.1.

#### **4.3.1 Equipment/Foundation Loads**

Equipment and foundation loads will be determined by the manufacturers using project-specific design criteria. Typical loadings used for design will include the following:

- Dead loads.
- Live loads.
- Operating loads.
- Wind loads.
- Seismic loads.
- Emergency loads.

Foundation loads furnished by the equipment manufacturers will be superimposed with loads for the foundation itself.

#### **4.3.2 Induced Forces**

The equipment will use steel anchor bolts, concrete expansion anchors, welds, and other equipment anchorage devices to resist equipment-induced forces.

#### **4.3.3 Structural System**

Foundations will typically consist of individual pads bearing directly on undisturbed soil or compacted fill. For equipment located in buildings, the pads may be constructed integrally with the grade slab.

#### **4.3.4 Structural Criteria**

Plant equipment will be designed to resist project-specific criteria in accordance with the manufacturers' standards and applicable codes and industry standards.

Environmental loading will be determined in accordance with Sections 3.1 and 3.2. Seismic loading will be calculated using equivalent static lateral forces applied at the center of gravity of the equipment or component in accordance with the criteria specified in Section 3.4.

Seismic lateral forces on equipment supported by structures will be determined in accordance with CBC Section 1632, with  $Z$  equal to 0.4,  $I_p$  equal to 1.5 for fire equipment and 1.0 for other equipment, and  $C_a$  in accordance with CBC Table 16-Q. Equipment bases, foundations, support frames, and structural members used to transfer equipment seismic forces to the main lateral load-resisting system will be designed for the same seismic load as the equipment.

Integral support structures provided by manufacturers with their equipment, such as the combustion turbine air inlet support structure, will be designed to resist, at a minimum, the lateral forces specified in CBC Section 1634, Nonbuilding Structures, and the applicable criteria of Section 3.4.

Load combinations will be as indicated in Section 3.2.6. These load combinations are in addition to those normally used in design and those specified in applicable codes and standards.

Equipment foundations will be designed and constructed as monolithic reinforced concrete structures using the criteria from Section 3.0 and Appendix H1, Section 3.1. The foundation design will address the following considerations:

- Allowable soil pressures.
- Allowable settlements.
- Equipment and environmental loads.
- Factors of safety against overturning and sliding.
- Equipment performance criteria.
- Access and maintenance.

Soil pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor of 3 against bearing failure. Total and differential settlements will be limited to the values specified in Appendix H1, Section 3.1.2.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

#### **4.3.5 Analytical Techniques**

Equipment foundations will typically be designed using static analysis techniques assuming a rigid mat. Foundations will be analyzed assuming a linear soil pressure distribution. Mats will be proportioned so that the resultant of the soil pressure coincides as nearly as possible with the resultant of the vertical loading.

Equipment will be designed and analyzed by the manufacturer to satisfy the requirements of the relevant codes and industry standards.

## 5.0 Hazard Mitigation

The project will be designed to mitigate natural and environmental hazards caused by seismic and meteorological events. This section addresses the structural design criteria used to mitigate these hazards.

### 5.1 Seismic Hazard Mitigation Criteria

Appendix H1 and this appendix describe the civil and structural design criteria that will be applied to the project.

Project seismic design criteria were selected based on the following considerations:

- Compliance with applicable laws, ordinances, regulations, codes, and life safety.
- Structural behavior and performance.
- Reliability of the plant.
- Financial impacts from seismically induced outages.
- Seismic probability and magnitude.

The project seismic design criteria were developed to incorporate these considerations using a systematic approach to correlate performance criteria with assumed risk level. The following procedure was used to establish the design criteria:

- The seismic hazards were assessed by studying the geologic features of the surrounding area. Major faults were identified, and information was collected regarding each fault's proximity, capability, recurrence, and magnitude.
- The seismic risk associated with each source was assessed considering historical magnitudes.
- Appropriate design criteria and analysis methods consistent with the seismic performance criteria were established for each major plant structure, equipment, and component.
- A site seismic Zone 4 was determined to be appropriate for structural design.
- CBC Figure 16-3 was selected to provide acceleration levels when using the CBC dynamic lateral force procedure. Acceleration levels for various structural frequencies will be based on CBC Figure 16-3, Design Response Spectra Shapes.

Specific design features that will be incorporated into the plant to mitigate the identified seismic hazards include the following:

- Appropriate analysis techniques will be employed to calculate structure-specific seismic loads.
- Plant structures, equipment, piping, and other components will be designed to resist the project-specific seismic loads.
- Critical equipment will be positively anchored to its supporting structure.

- Anchorages will be designed to resist project-specific seismic loadings.
- Adequate factors of safety against overturning and sliding due to seismic loads will be provided.
- The design of piping connections to structures, tanks, and equipment will consider differential seismic displacements between components.
- Adjacent structures will be seismically isolated from one another.
- Structural elements will be designed to comply with special detailing requirements intended to provide ductility.
- Connections for steel structures will have a minimum load carrying capability without regard to the calculated load.
- Lateral and vertical displacements of structures and elements of structures will be limited to specified values.
- Appropriate measures will be taken to prevent saturation of foundation soils and eliminate the potential for soil liquefaction.

The foregoing design features are intended to provide the degrees of safety for structures and equipment as follows:

- Resist minor earthquakes without damage. Plant remains operational.
- Resist moderate earthquakes without structural damage but with some nonstructural damage. Plant remains operational or is returned to service following visual inspection and/or minor repairs.
- Resist major earthquakes without collapse but with some structural and nonstructural damage. Plant is returned to service following visual inspection and/or moderate repairs.

## 5.2 Meteorological and Climatic Hazard Mitigation

Meteorological and climatic data were used to establish the project design basis. Portions of the data and the design bases that pertain to structural engineering are provided in this appendix.

Specific design features which will be incorporated into the plant to mitigate meteorological and climatic hazards include the following:

- Structures and cladding will be designed to resist the wind forces.
- Sensitive structures will be designed for wind-induced vibration excitation.
- Roofs will be sloped and equipped with drains to prevent accumulation of rainfall.
- Site drainage systems will be designed to convey the runoff from a 25 year storm event with a time of concentration of 10 minutes.
- Ground floor levels of structures will be placed above probable flood levels.

- Building drainlines will be installed with backflow prevention devices where necessary.
- The bases of plant equipment will be placed above probable flood levels.
- The plant site will be graded to convey runoff away from structures and equipment.

The foregoing design features will be incorporated in accordance with the applicable codes and standards identified in this appendix.

The degree of safety offered by these features is consistent with the requirements of the applicable codes and standards and the economic benefits these features provide.